AN ECONOMIC STUDY OF U.S. AIRCRAFT HIJACKING, 1961-1976*

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"Well, I could stop hi-jackers tomorrow . . . if everyone was allowed to carry guns them hi-jackers wouldn't have no superiority. All you gotta do is arm all the passengers, then no hi-jacker would risk pullin' a rod." Archie, "All in the Family."

I. INTRODUCTION

ON May 1, 1961 a National Airlines aircraft en route from Miami to Key West was successfully hijacked and diverted to Cuba. Although aircraft hijackings had occurred in Eastern Europe and Cuba prior to that date, this was the first recorded hijacking of a U.S. registered aircraft.[1] Seven more U.S. hijackings took place between 1961 and 1967 (see Table 1), followed by an unprecedented increase in the next five years. Between 1968 and 1972, 124 hijackings occurred, leading some observers to proclaim that hijacking had become a national epidemic.[2] This surge of hijacking, however, came to an abrupt halt in 1973—one hijacking took place in that year and only ten more occurred in the next three years. A similar pattern of hijackings is

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[1] In this paper the term "hijacking" refers to air carriers and excludes the category of general aviation (for example, small aircraft such as Pipers, Cessnas, and so forth). Note also that the Federal Aviation Administration (FAA) defines a hijacking to include one in which the offender is unsuccessful (for example, he is captured before gaining control of the aircraft). Thus, the number of hijackings per year in my study includes both actual and attempted hijackings.

[2] Even during the peak year 1969, however, the probability that an aircraft would be hijacked on any given day in the United States was negligible ($= .70\ 10^{-5}$). Yet this was more than 300 times greater than the probability that an individual would be murdered on a given day ($= .20\ 10^{-6}$).

found outside the United States—relatively few incidents (19) between 1961 and 1967, a sharp increase (174) from 1968 to 1972, and a decline (56) thereafter.

What accounts for the dramatic reduction in U.S. hijacking after 1972, and how does one explain the pattern of hijackings in general? Is deterrence—measured by rates of apprehension, the likelihood of incarceration, and the severity of sanctions—an important explanation of the time series behavior of aircraft hijackings? Did the security measures introduced in the 1970s, in particular, mandatory preboard screening of passengers and carryon luggage, lead to significantly fewer hijackings? What were the costs of these security measures relative to the number of hijackings prevented? Alternatively, was hijacking simply a fad that would have lost momentum and sharply declined after 1972 without the imposition of elaborate security measures? The present study attempts to answer these and other questions, focusing mainly on U.S. aircraft hijacking.

Table 1 suggests that deterrence may be an important explanation of hijackings in the United States. Between 1961 and 1965, the proportion of offenders apprehended (within one year of the hijacking) was .80 and the rate of hijacking was low.[3] During the peak years, 1968-1972, the proportion apprehended declined to a low of .15 in 1968 then rose steadily to .60 in 1972. By contrast, all offenders were apprehended from 1973 to 1976, and the number of hijackings substantially declined. The broad pattern of sentencing is also consistent with the view that deterrence matters. Sentences were relatively low and variable to those convicted through 1971. But in the years 1972 to 1974—when nearly 50 per cent of apprehended hijackers were sentenced—the sentences meted out were severe, averaging almost 30 years per convicted offender.[4] Hijacking also imposes another significant risk on the offender—the chance of being shot and killed during the attempt. No offenders were killed until the third quarter of 1971, but since then more than 10 per cent (7 of 68) were killed during attempted hijackings.

The implementation of several security measures aimed at reducing the incidence of hijacking coincides with increases in the probability of apprehension. For example, in 1970 the major airlines began to use weapon-screening devices on passengers meeting a behavioral profile of a hijacker.[5]

[3] Unless stated otherwise, apprehensions always refer to offenders apprehended within a year of the hijacking. Note that 84% of all apprehensions occurred within a year of the hijacking. See Federal Aviation Administration-Civil Aviation Security Service, Chronology of Hijackings of U.S. Registered Aircraft and Current Legal Status of Hijackers, as of July 1, 1976 (mimeo).

[4] Statutory changes, however, do not appear responsible for the observed increase in sentences. The only congressional enactment dealing with sentences is the 1961 amendment to the Federal Aviation Act of 1958, 49 U.S.C. § 1472 (1961) that made aircraft hijacking a federal crime punishable by death with a minimum sentence of 20 years.

[5] The profile consists of a list of about a dozen characteristics. Although the airlines and the

TABLE 1
DOMESTIC AND FOREIGN AIRCRAFT HIJACKINGS

	1930-1960	1961-1965	1966-1967	1968	1969	1970	1971	1972	1973	1974	1975	1976[4]	Total 1961-1976[4]
U.S. Air Carrier Aircraft[1]													
Hijackings		8	0	16	38	20	23	27	1	3	6	1	143
Offenders		10	0	26	52	22	28	40	1	3	6	5	193
Proportion of offenders apprehended within 12 months		.80	—	.15	.29	.41	.50	.68	1.0	1.0	1.0	1.0	
Proportion of offenders who attempted to go to Cuba[2]		.60	—	.92	.96	.73	.64	.25	0	0	.17	0	
Average sentence (in years) during time interval[3]		16.3	4	1.5	10	21	6.8	32.1	23	41.7	13.3	14.3	
Number of persons sentenced to prison		3	2	1	2	7	6	12	10	3	6	4	56
U.S. General Aviation													
Hijackings		2	1	4	0	2	2	4	1	4	6	1	27
Offenders		4	1	4	—	3	3	6	1	6	9	1	38
Proportion of offenders apprehended within 12 months		.50	0	.75	—	.33	.67	.33	1.0	.83	.89	1.0	
World (excluding U.S.)													
Hijackings (excluding general aviation)	44	11	8	12	46	54	32	30	20	17	13	6	249
Offenders		45	47	23	129	152	60	79	45	27	19	17	643
Proportion of offenders apprehended within 12 months		.40	.50	.22	.27	.31	.62	.67	.53	.56	.68	.87	

Notes:

[1] Our definition of a domestic hijacking excludes hijackings of U.S. registered aircraft in foreign countries. The FAA's Civil Aviation Security Service includes these hijackings (of which there have been 11 since 1961) in their enumeration of domestic hijackings.

[2] If Cuba was one of several stated destinations and the hijacking was not completed, this was included in the Cuba class.

[3] Life imprisonment defined as 50 years for the purpose of computing average sentences.

[4] As of July 1, 1976.

Source: Federal Aviation Administration, Civil Aviation Security Service, Chronology of Hijackings of U.S. Registered Aircraft and Current Legal Status of Hijackers, as of July 1, 1976; Federal Aviation Administration, Civil Aviation Security Service, Domestic and Foreign Aircraft Hijackings as of July 1, 1976.

And beginning in the fourth quarter of 1970, air marshals, who numbered about 1,200 at their peak, were riding shotgun on selected flights.[6] The most significant security measure was the executive order requiring all the nation's airlines by January 5, 1973 to search electronically carryon luggage and passengers for possession of weapons. From that day on, all hijackers were apprehended. In addition to these explicit security measures, the United States and Cuba entered into a treaty on February IS, 1973, calling for both nations to extradite or punish hijackers. Since Cuba had been the principal destination of U.S. hijackers, at least through 1971 (see Table 1), the enforcement of this treaty meant that the probability of apprehension would be near unity for an aircraft successfully diverted to Cuba.

A preliminary discussion of deterrence would be incomplete without some mention of the types of hijackers. Until 1972 the primary objective of hijackers was to obtain "free" transportation to Cuba, in some cases for political purposes and in others to avoid prosecution for crimes in the United States. The Cuban connection began to taper off in 1970 (for example, 96 per cent of the offenders in 1969 attempted to reach Cuba compared to 73, 64, and 25 per cent in the next three years) as information on the treatment of hijackers in Cuba became available in the United States, partly from hijackers who had voluntarily returned.

A new breed of hijackers, known as parajackers, appeared in late 1971. A parajacker demanded both ransom money and a parachute to escape from the seized aircraft. The first such individual, the alias "D. B. Cooper," parachuted en route to Reno with $200,000. Neither Cooper nor the ransom money has ever been found. This was followed by seventeen more attempts in which ransom demands averaged over $300,000. None were successful—five offenders were apprehended after their jumps, three were shot and killed, another was shot and captured, and eight more were captured. Of the eleven sentenced to prison (three others were committed to mental institutions), the average sentence was forty-three years. This was indeed a risky activity—one success in eighteen tries with severe penalties for failure—and by the end of 1972 the expected returns were sufficiently low to discourage any further attempts.[7]

FAA have attempted to keep the contents of the profile secret, some of the identifying characteristics have been published. These characteristics include males between the ages of IS and 55, purchasers of one-way tickets, and persons paying in cash. See Douglas M. Kraus, Searching for Hijackers: Constitutionality, Costs, and Alternatives, 40 U. Chi. L. Rev. 383 (1973) for a discussion of the various security measures.

[6] The number of sky marshals today is less than 100, and only on rare occasions do they ride shotgun (see Trained and Ready: The Air Marshals Carry On, 6 FAA World 8 (1976).

[7] All parachute jumps were from Boeing 727s and DC 9s. A modification on the rear door of these planes prevented their opening during flight. This greatly increased the risk of a jump and reduced the offender's expected return since he was likely to be hit by the plane as he exited

Finally, one might speculate on the sanity of hijackers in recent years in view of the low probabilities of success and the severe sanctions. To be sure, a substantial number of lunatics have engaged in this activity. Of the approximately seventy-two offenders apprehended (excluding seven juveniles), roughly one-quarter were sent to mental institutions (seventeen of seventy-two offenders). Yet the proportion committed to mental institutions is not very different in the period before 1973, when about 40 per cent of hijackers were apprehended, compared to the 1973-1976 period when all were apprehended. Two of twelve offenders in 1973-1976 were committed to mental institutions compared to fifteen of sixty in the earlier period, suggesting that lunatics are no less deterred by a high probability than other potential offenders.

The organization of the paper is as follows. Part II sets out the underlying deterrence model of the hijacking offense function. Part III describes the variables used in the study and presents several estimates of the offense function. Part III also attempts to distinguish between the deterrence and "fad" hypotheses as explanations of the time series behavior of hijacking. Part IV contains estimates both of the number of hijackings deterred since 1972 by the use of mandatory searches at airports and of the net costs of this security procedure relative to its benefits. Part V presents a summary of the results and concluding remarks. An appendix contains an empirical analysis of the determinants of the probability of apprehension and the severity of sanctions.

II. THE BASIC DETERRENCE MODEL

The economic approach to criminal behavior, which has been developed in the pioneering works of Becker[8] and Ehrlich,[9] assumes that persons choose between legal and illegal activities on the basis of expected utility maximization. Adapting this model to hijacking, I write the potential offender's expected utility from hijacking an aircraft from country *i toj (i* may be identical to *j)* as

$$\bar{U} = (1 - P_a)U(W_j) + P_aP_cU(W_i - S) + P_a(1 - P_c)U(W_j - C), \quad (1)$$

where P_a equals the offender's estimate of the probability of apprehension

from a forward door. Note that I have excluded from the class of parajackers offenders who had demanded ransom and a parachute but chose instead to divert the aircraft to Cuba or another country.

[8] See Gary S. Becker, Crime and Punishment: An Economic Approach, 76 J. Pol. Econ. 169 (1968).

[9] See Isaac Ehrlich, Participation in Illegitimate Activities: A Theoretical and Empirical Investigation, 81 J. Pol. Econ. 521 (1973).

(assumed to occur in i), P_c is the conditional probability (given apprehension) of conviction and incarceration, W_j and W_i the offender's wealth (including the monetary equivalent of nonpecuniary income) in country j and i respectively, S the monetary equivalent of the sentence in i, and C the monetary equivalent of the costs associated with apprehension when the offender is not sentenced (for example, detention awaiting trial, costs of probation, lawyer's fees). Letting $U = U(W_i)$ denote the utility from not attempting to seize an aircraft, the potential offender will commit or refrain from committing the offense depending on whether $\bar{U} \gtrless U$. Note that a necessary condition for $\bar{U} > U$ is that the offender's full wealth in j must be greater than in i (that is, $W_j > W_i$).[10]

Equation (1) implies that the greater P_a, P_c, S, and C, and the smaller the differential between W_j and $W_i (W_j > W_i)$, the lower $\bar{U}$ is and the less likely the offender is to attempt to hijack an aircraft. Aggregating among potential offenders, one can write the aggregate offense function in time t as

$$O = O(\bar{P}_a, \bar{P}_c, \bar{S}, \bar{C}, \bar{Z}, \bar{X}), \tag{2}$$

where $\bar{P}_a$, $\bar{P}_c$, $\bar{S}$, and $\bar{C}$ are the average values in period of t of the variables specified in equation (1), $\bar{Z}$ is a vector of variables denoting the average wealth differential between country j and i in period t, and $\bar{X}$ denotes the combined effect of other variables. The analysis predicts that the level of offenses in period t will be negatively related to the values of $\bar{P}_a$, $\bar{P}_c$, $\bar{S}$, and $\bar{C}$, and positively related to $\bar{Z}$.[11]

[10] To simplify the presentation I have assumed only two adverse outcomes: a sentence S if one is convicted, and costs C if one is apprehended but not convicted. Actually there are multiple adverse outcomes: the offender may be killed in the attempt; there may be a variety of sentences, including commitment to a mental institution; and the sentence may differ depending on the type of hijacking and the time the offender is apprehended. Further, the offender may be apprehended in country j and extradited to i for sentencing, or he may be both apprehended and sentenced in country j, contrary to our simplifying assumption that he is apprehended and convicted in country i. Moreover, there may be many possible wealth outcomes in j, not a single outcome. One could incorporate this feature into the analysis by substituting $(1 - P_a) \Sigma \pi_j U(W_j)$ in equation (1) where π_j denotes the probability of the j^{th} outcome. This points out that *ex post* the offender may be worse off in j than i (for example, the offender's wealth in Cuba was less than expected) and yet *ex ante* the expected wealth in j was sufficiently greater than in i to make $\bar{U} > U$.

[11] A central feature of Ehrlich's analysis, the simultaneity between offenses and the probabilities of apprehension, conviction, and so forth, has not been used in this paper. In Ehrlich's analysis, for example, $\bar{P}_a$ is an endogenous variable that depends, in part, on the level of offenses. That is, given the level of law enforcement, an increase in offenses lowers the probability of apprehension since fewer resources are spent in attempting to apprehend the average offender. A priori the simultaneity problem does not appear important in this study. Two hijackings have never taken place at the same airport on the same day. Moreover, except on two occasions, hijackings have taken place on different days. Given the standby enforcement capability, the observed rate of hijacking (even at peak periods) would seem insufficient to strain the enforcement capacity and make the probability of apprehension a negative function of

III. EMPIRICAL ANALYSIS OF HIJACKING

A. *Discussion of Variables*

The major difficulty in estimating the aggregate offense function is the limited number of observations in the hijacking sample. Since an annual time series analysis would contain at most sixteen observations (1961-1976), I have chosen the following alternatives to annual data.

1. *Quarterly Hijackings (HJK).* Although a quarterly time series substantially expands the number of observations to more than sixty, no hijackings took place in about half the quarters. It would be misleading to delete these quarters because the fact that no hijacking occurred is valuable information for a deterrence study. But since these quarters have no offenders, there is no direct information on the probability of apprehension and conditional probability of conviction. To deal with this problem, I have estimated quarterly regressions on the probability of apprehension and conditional probability of incarceration, filling in the missing quarters with the predicted values from the regression equation. A similar problem of missing observations arises in assigning sentences to each quarter. Data are available on the sentences of only fifty-six offenders in twenty-seven quarters. However, by approximating the anticipated sentence in a quarter as an average of four past quarters, sentence estimates for most quarters can be obtained. A second problem with quarterly data is that quarterly changes in the deterrence variables may contain a relatively large random component, tending to bias the regression coefficients toward zero. To reduce the error component and increase the reliability of the results, I have used moving averages of the deterrence variables.[12]

2. *Time Interval (TINT).* An alternative method of estimating the frequency of hijacking is to order the 143 incidents according to the date of their occurrence and compute the time interval (in days) between successive hijackings. Since the reciprocal of the interval is an estimate of the probability of a hijacking on a given day,[13] one would predict this probability to fall

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the rate of hijacking. One could plausibly argue the reverse. A larger number of offenses in a period would increase the precautionary measures undertaken by airport guards, ticket agents, pilots, attendants, and so forth in *that* period, tending to increase $\bar{P}_a$ in periods of peak hijackings. This in turn would bias downward estimates of deterrence effects. I have attempted to deal with this problem by utilizing lagged values of deterrence variables in the regression analysis.

[12] I also tested the possibility of a systematic seasonal factor in hijacking by including a set of dummy variables to denote the quarter. The dummy variables were insignificant (individually and taken as a set) and had negligible effects on the other independent variables. The reported regressions exclude the dummy seasonal variables.

[13] Let p = the daily probability of a hijacking, then the expected duration between two successive hijackings is

and the time interval between observations to lengthen in response to increases in the levels of deterrence.[14] The principal advantages of this approach are the expansion in the number of observations in the regression analysis and the availability of information on the apprehension and incarceration of the individuals involved. The disadvantage is that the more successful deterrence is, the smaller is the proportion of observations available to measure the response of offenders to deterrence. Imagine little change in the probability of apprehension prior to 1973 but a large increase that substantially eliminated hijackings after 1973. In this case, there would be relatively few observations with high probabilities of apprehension, making it difficult to observe a significant deterrent effect. In the limit, if deterrence fully eliminated hijacking, there would be no observation in the sample measuring this phenomenon. In contrast, a quarterly time series would still contain a large number of observations with both zero hijacking and a high estimated probability of apprehension.

3. *Flight Interval (FINT).* A variant of the time interval is the number of air carrier flights between successive hijackings. Since the expected value of the latter interval equals the reciprocal of the probability a flight is hijacked, one expects a lengthening in the flight interval in response to an increase in the level of the deterrence variables. The number of flights between successive hijackings can be estimated from monthly data on air carrier flight operations, assuming a uniform monthly distribution of operations. Note that a flight operation is defined as either a takeoff or landing, and hence the number of flights is one-half the number of operations.

A discussion of the independent variables used to estimate the hijacking offense function is presented below. For convenience I have included Table 2, which presents a brief description of the variables in the empirical analysis.

3. *Probability of Apprehension* (P_a^h, P_a^o). The following estimates of the offender's forecast of the probability of apprehension in quarter t were utilized:[15] (1) a moving average (P_a^h) of the proportion of hijackings in which

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$$E(TINT) = p(1) + (1 - p)p(2) + (1 - p)^2p(3) + \ldots + (1 - p)^{n-1}p(n)$$
$$= p\,\partial[(1 - p)/p]/\partial(1 - p) = 1/p.$$

[14] Richard Quandt in two statistical studies of aircraft hijacking (see Richard E. Quandt, Some Statistical Characterizations of Aircraft Hijacking, 6 Accid. Anal. & Prev. 115 (1975); and Der-Ann Hsu & Richard E. Quandt, Statistical Analyses of Aircraft Hijacking and Political Assassinations (1976) (mimeo, Econometric Research Program, Princeton U.) used the time interval between successive hijackings (also called the interoccurrence time) to test and reject the hypothesis that the pattern of U.S. aircraft hijackings was generated by a homogeneous Poisson process. In the second paper, Quandt allowed the Poisson intensity period parameter to vary for each hijacking occurrence and speculated on reasons (for example, differences in deterrence) for variations in this parameter, but he did not systematically test the effects of deterrence or other variables.

[15] All estimates first require a continuous quarterly series on the probability of apprehension.

TABLE 2
DEFINITION OF VARIABLES

Variable Name	Definition	Mean	Standard Deviation
HJK	number of domestic hijackings per quarter	2.27	3.43
TINT	time interval (days) between successive hijackings	40.0	147.9
FINT	number of flights between successive hijackings (thousands)	486	1614
P_a^h, $\hat{P}_a^h$, P_a^o, $\hat{P}_a^o$	probability of apprehension within 4 quarters—hijacking (h), offenders (o), and predicted ($\hat{}$)	.607 (h)	.240
		.627 ($\hat{h}$)	.212
		.590 (o)	.245
		.608 ($\hat{o}$)	.218
P_c, $\hat{P}_c$	conditional probability of incarceration (*i.e.*, prison and mental institution)—predicted ($\hat{}$)	.782	.141
		.793 ($\hat{}$)	.080
S, $\hat{S}$	average sentence of persons sentenced in 4 prior quarters (S) and predicted sentence in current quarter ($\hat{S}$)	16.22 (S)	10.04
		16.13 ($\hat{S}$)	
P_k	proportion of offenders killed in 3 prior quarters	.084	.231
OPER	air carrier flight operations per quarter (thousands)	2237	327
U	quarterly unemployment rate of civilian labor force, seasonally adjusted	5.29	1.36
POP	quarterly population (millions)	201	9.57
Y	quarterly per capita personal consumption expenditures—1972 dollars (thousands)	3.14	.393
FHJK	number of foreign hijackings per quarter	3.95	4.96
TIME	time in quarters		

Note: Means and standard deviations refer to quarterly values of variables 1st quarter 1961–3d quarter 1976, except for *TINT* and *FINT* variables.

Sources:

(1) Federal Aviation Administration (FAA), Civil Aviation Security Service, Domestic and Foreign Hijackings, as of July 1, 1976 (mimeo)—all variables except *OPER*, *U*, *POP*, *Y*.

(2) Monthly and quarterly data on *OPER* provided by *FAA*.

(3) *U* from U.S. Dep't of Labor, Monthly Labor Review (1962-76).

(4) *POP* from various vols. of Bureau of the Census, Current Population Reports (1961-76).

(5) *Y* from various years of the Economic Report of the President (1963-77).

offenders were apprehended in quarters $t-1$, $t-2$, and $t-3$; (2) a moving average (P_a^o) of the proportion of offenders apprehended in quarters $t-1$, $t-2$, and $t-3$;[16] (3) the predicted value ($\hat{P}_a^h$) estimated from a linear regres-

Missing quarters were estimated from a regression on the probability of apprehension with the following independent variables: the number of offenders per hijacking, the size of the flight crew, age and age-squared of offenders, flight operations, dummy variables for the period when air marshals were riding shotgun and for the period when mandatory searches were required, and time. Missing values were then filled in by using the mean values for offenders, flight crew, age, age square, and the actual values for the two dummy variables. For further discussion see the Appendix.

[16] To illustrate the difference between estimates (1) and (2), consider the following example. Suppose two hijackings occur in quarter t and there is one offender in the first not apprehended

sion of P_a^h in t on the probabilities in the three previous quarters; and (4) the predicted value ($\hat{P}_a^o$) estimated as in (3). In addition, when (3) and (4) are utilized, I tested the hypothesis that the residual from the actual probability in period t is unanticipated and, therefore, has no deterrent effect.

4. *Conditional Probability of Incarceration* (P_c, $\hat{P}_c$). This is defined as the proportion of offenders apprehended (excluding those killed) who were either sentenced to prison or committed to a mental institution.[17] Two estimates of the conditional probability in quarter t were utilized. P_c is a moving average of the conditional probabilities in quarters $t-1$, $t-2$, and $t-3$, and $\hat{P}_c$ is the predicted value of the conditional probability from a regression of the conditional probability in quarter t on the three previous quarters.

5. *Sentence* (S, $\hat{S}$). The average sentence expected by the potential hijacker in quarter t is approximated either by the average sentence (S) of all persons sentenced in the four quarters prior to t or by the predicted sentences ($\hat{S}$) from a simple regression of S in the current quarter on its value in the previous quarter. Observe that persons sentenced in quarter t may have committed offenses in any of the previous quarters. The most extreme example is the first offender (May 1961), who was arrested fourteen years later in 1975 and sentenced to twenty years. His twenty-year sentence is included in the first quarter of 1976 for purposes of computing the average sentence.[18] Note that the theoretically correct variable is the actual time served, not the sentence. Since data on actual time served are unavailable because of recent long sentences, one must use sentences, implicitly assuming they are proportional to time served.

6. *Conditional Probability of Death* (P_k). I indicated earlier that offend-

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and three offenders in the second all apprehended. The proportion of offenders apprehended (estimate (2)) equals .75 while the proportion of hijackings in which offenders are apprehended (estimate (1)) equals .50. A priori it is not clear which method is preferable. One could argue that as a first approximation there would be no difference between the two in equilibrium because, if there was, potential offenders would adjust the number involved in a given hijacking. If the full costs of planning a multiple-offender hijacking were greater, then the equilibrium probability would tend to vary negatively with the number of offenders. We take up this question in the Appendix. Fortunately, the offender and hijacking apprehension probabilities are highly correlated (about .99) and the results are generally unaffected by which of the two sets of estimates are included in the offense function.

[17] Since observations on the conditional probability are available for only 27 quarters, values for the missing quarters were estimated using the coefficients from a regression on the conditional probability in the 27 quarters with data. Unfortunately, with the exception of time, the variables in this regression (number of offenders, degree of success of the hijacking, race and age of offender, presence of extortion, and apprehension outside the United States) all require data that are obviously not available for the missing quarters. Thus, missing values were estimated using the constant, time, and the mean values of the remaining variables. Therefore, my estimates of the conditional probability are probably subject to sizable error.

[18] When the date of arrest is given but not the date of sentence, I assumed that the offender was sentenced in the quarter following his arrest. This assumption corresponds to the typical lag between arrest and sentencing when information on both is available.

ers, at least after 1971, faced non-negligible probabilities of being shot and killed during the attempted hijacking. To the extent that this event is anticipated, it would reduce the expected gains and hence the incentive to commit hijacking. One can test this hypothesis by including in the offense function a variable measuring the conditional risk of death in each quarter (P_k). The latter is approximated by the ratio of offenders killed to the number apprehended in the prior three quarters.[19]

7. *Flight Operations* (*OPER*). In order to standardize for the opportunities to hijack an airplane or alternatively for the number of potential "victims," I included in the offense function the number of air carrier operations per quarter. Other things constant, the greater the opportunities, the greater the number of hijackings. The potential importance of distinguishing opportunities from deterrence is illustrated by the fact that flight operations were sharply cut back beginning in the fall of 1973 (which coincided with increases in the probability of apprehension) in response to the oil price rise and the economic recession.

8. *Population* (*POP*). Just as flight operations measure changes in the supply of potential "victims," one would also like to include an estimate of changes in the supply of potential offenders. Quarterly estimates of the population were included in the offense function to approximate changes in the underlying supply of offenders.[20]

9. *Economic Variables* (U, Y). The theoretical analysis predicts that the incentive to engage in illegal relative to legal activities depends on the differential returns between the two. Although direct observations on the differential are not available, unemployment (U) and per capita personal consumption expenditures (Y) in the United States may roughly measure this differential. Other things constant, a reduction in U and an increase in Y would indicate improved legal opportunities and should reduce the number of hijackings. Two obvious problems, however, are associated with these measures. Changes in U and Y in the United States may be correlated with similar changes outside the United States. Thus, persons planning to leave the United States would be unresponsive to changes in U and Y. Secondly, changes in U reflect mainly cyclical, not permanent or long-run, changes in economic conditions, whereas the theoretical analysis stresses permanent changes. This is particularly important since a decision to seize an aircraft and leave the country often means a permanent and irreversible wealth

[19] Thus, P_k is zero for all quarters through the third quarter of 1971, in which the first hijacker was shot and killed.

[20] A better measure of potential hijackers is males over eighteen years of age since hijackers are primarily from this subgroup. Quarterly data on this subgroup are not available, although one can approximate quarterly values from quarterly data on the entire population. Although there is little gain from this approach, I experimented with it in several regressions and found negligible differences compared to the *POP* variable.

change. In contrast, other illegal activities within the United States may be highly responsive to cyclical changes since one can exit and enter the legal market as economic conditions change. For this reason I used consumption expenditures instead of current income as a rough measure of permanent income.

B. *Quarterly Results*

Table 3 presents estimates of linear regressions on the number of U.S. hijackings per quarter from 1961 to 1976.[21] Equations (1) and (4)-(6) are modified first differences, estimated via the Cochrane-Orcutt technique, and for comparative purposes I include a first-difference (eq. (2)) and a level (eq. (3)) equation.

Despite obvious shortcomings in the data (for example, the use of quarterly changes and missing quarterly values of deterrence variables), the findings strongly support the deterrence hypothesis. The probability of apprehension (P_a^h, P_a^o, $\hat{P}_a^h$, and $\hat{P}_a^o$) has a negative and highly significant effect in all equations. Moreover, the magnitude of this effect is substantial. To illustrate, an increase in the probability from .75 to .95, which corresponds approximately to the observed increase from 1972 to 1973-1976, is associated with 1.1 to 2.2 fewer hijackings per quarter in Table 3. The regression coefficients on the conditional probability of incarceration (P_c and $\hat{P}_c$) are also negative but generally less significant (as expected in view of the relatively small variation in this variable).[22] Here an increase of .10 in the conditional probability reduces the number of hijackers between .5 and 1.3 per quarter. Similarly, an increase in the sentence is associated with a statistically significant reduction in the number of offenses. For example, a ten-year increase leads to .8 to 1.6 fewer offenses per quarter. Although the conditional probability of being shot and killed (P_k) has a negative effect in all equations, it is at best marginally significant. The lack of significance may be due to probable errors in estimating P_k that arise, in part, from the circumstances surrounding the killing of offenders. An analysis of the seven offenders killed reveals that four were involved in shoot-outs with law enforcement authorities in which other persons were either wounded or killed. Possibly, these offenders could have avoided being killed if they had chosen

[21] A logarithmic transformation of the variables is typically used in other empirical estimates of offense functions (see Isaac Ehrlich, *supra* note 9). I have not used it here because of the large number (32) of quarters in which there were zero hijackings. The latter suggests that a Tobit analysis, where one estimates both the probability of a hijacking occurring and the frequency of hijackings, would have been appropriate for the quarterly hijacking data. However, I have not estimated any offense functions using the Tobit method.

[22] The small variation (for example, the coefficient of variation averages about .2) is due to the method of estimating values for missing quarters where the only source of variation was time (see note 17 *supra*).

TABLE 3

QUARTERLY HIJACKINGS (*HJK*), FOURTH QUARTER 1961–THIRD QUARTER 1976, MODIFIED FIRST DIFFERENCES, FIRST DIFFERENCES AND LEVELS

(*t*-values in parentheses)

Independent Variables	(1) CORC ($\hat{\rho}$ = .589)	(2) OLS ($\hat{\rho}$ = 1)	(3) OLS ($\hat{\rho}$ = 0)	(4) CORC ($\hat{\rho}$ = .577)	(5) CORC ($\hat{\rho}$ = .659)	(6) CORC ($\hat{\rho}$ = .642)
P_a^h	−11.110	−9.708	−10.958			
	(3.040)	(2.327)	(2.961)			
P_a^o				−10.743		
				(3.112)		
$\hat{P}_a^h$					−5.783	
					(2.010)	
$\hat{P}_a^o$						−5.374
						(2.074)
P_c	−6.867	−7.654	−4.742	−6.424		
	(1.518)	(1.762)	(.998)	(1.442)		
$\hat{P}_c$					−12.730	−10.867
					(2.334)	(1.986)
S	−.129	−.163	−.082	−.139		
	(2.265)	(2.609)	(1.580)	(2.446)		
$\hat{S}$					−.140	−.147
					(2.075)	(2.184)
P_k	−1.319	−1.288	−2.347	−1.490	−1.430	−1.481
	(.812)	(.826)	(1.212)	(.917)	(.887)	(.915)
OPER	−.002	−.004	.0002	−.003	−.001	−.001
	(.802)	(1.228)	(.061)	(.850)	(.363)	(.327)
POP	1.333	.822	.870	1.141	1.837	1.805
	(1.142)	(.354)	(1.210)	(.986)	(1.433)	(1.452)
U	1.177	1.204	1.204	1.155	1.091	1.152
	(1.456)	(1.252)	(2.056)	(1.444)	(1.285)	(1.373)
Y	10.684	11.859	9.717	8.700	11.079	10.778
	(.979)	(.986)	(1.136)	(.799)	(.992)	(.970)
TIME	−.685		−.480	−.553	−1.007	−.999
	(.989)		(1.028)	(.797)	(1.374)	(1.398)
Constant	−264.2	−.514	−182.9	−223.7	−357.4	−352.7
	(1.181)	(.388)	(1.309)	(1.006)	(1.966)	(1.490)
R^2			.56			
D.W.	1.84	2.16	.96	1.82	1.83	1.84
Number of Observations	59	59	60	59	59	59

Note: For equations (1), (4), (5), and (6) all variables (X) are of the form $X_t - \hat{\rho}X_{t-1}$, where $\hat{\rho}$ is estimated via the Cochrane-Orcutt iterative procedure (CORC).

not to engage in a gun battle. This suggests that the observation that prior offenders were killed (which determines the estimated value P_k) would not necessarily increase the current offender's estimate of P_k, providing he chose not to engage in a gun battle. Finally, observe that the elasticities, computed at the mean values, of the deterrence variables (with the exception of P_k) are relatively large—1.4 to 3.0 for P_a, 1.6 to 4.5 (the latter for the $\hat{P}_c$ estimate), and .6 to 1.2 for the sentence.

As a further test of the deterrence hypothesis, I reestimated equations (5) and (6) entering the residuals (that is, the actual minus the predicted values of $\hat{P}_a$, $\hat{P}_c$, and $\hat{S}$) of the deterrence variables as independent variables. Since one can interpret the residuals as the unsystematic or nonforecasted component, I would not expect them to have any significant deterrent effect. Not only was each residual insignificant but jointly they were also insignificant.

In contrast to the findings on deterrence, the nondeterrence variables have no highly significant effects on the number of quarterly hijackings. The regression coefficients on population (*POP*) and unemployment (*U*) are in the predicted direction and sometimes marginally significant. The coefficients on flight operations (*OPER*) are negative in five equations and insignificant in all six. Per capita consumption (*Y*) is positive but always insignificant. The time trend variable is negative but never significant.

C. *Time Interval Results*

Table 4 presents regression equations on the natural logarithm of both the time interval (equations (1) and (2)) and flight interval (equations (3) and (4)) between successive hijackings. The effects of the deterrence variables in these equations are similar to their effects on quarterly hijackings. Increases in the probability of apprehension, the conditional probability of incarceration, and sentence are generally associated with statistically significant increases in the time and flight intervals between successive offenses,[23] which in turn translates into a reduction in the number of hijackings per time period.[24] To illustrate, an increase in the probability of apprehension of .2 lengthens the time interval (at its mean value) from 40 days to between 58 and 66 days—which is equivalent to a .7 to .9 decline in hijackings per quarter (that is, from about 2.3 to between 1.6 and 1.4). This compares to the 1.1 and 2.2 reduction estimated from the quarterly regressions of Table 3. Similarly, a ten-year increase in the average sentence is associated with a .6 reduction in hijackings per quarter (from 2.3 to 1.7), compared to a .8 to 1.6 estimated reduction in Table 3. The remaining deterrence variable, the conditional probability of being killed, is insignificant in all regressions in Table 4.

All the other variables in Table 4 are significant except flight operations.[25]

[23] To economize on space, Table 4 does not contain results on the alternative measure of the probability of apprehension (P_a'' and $\hat{P}_a''$) used in Table 3. The results on P_a'' and $\hat{P}_a''$, however, are virtually identical to those on P_a^h and $\hat{P}_a^h$.

[24] It also follows, therefore, that an increase in the deterrence variables reduces the probability of a hijacking on both a given day and flight (see note 13 *supra*).

[25] Flight operations are not included as an independent variable in the flight interval analysis since the flight interval equals *TINT* multiplied by the average number of daily flights during the time interval.

TABLE 4
TIME INTERVAL (*TINT*) AND FLIGHT INTERVAL (*FINT*) BETWEEN SUCCESSIVE HIJACKINGS: OLS REGRESSIONS, FOURTH QUARTER 1961–THIRD QUARTER 1976
(*t*-values in parentheses)

Independent Variables	*TINT*		*FINT*	
	(1)	(2)	(3)	(4)
P_a^h	3.309		3.348	
	(3.779)		(4.120)	
$\hat{P}_a^h$		2.262		2.412
		(2.678)		(3.010)
P_c	2.647		2.634	
	(1.989)		(1.995)	
$\hat{P}_c$		4.259		4.203
		(2.381)		(2.355)
S	.033		.034	
	(1.789)		(1.927)	
$\hat{S}$		.033		.037
		(1.582)		(1.794)
P_k	−.700	.103	−.523	.450
	(.373)	(.054)	(.286)	(.241)
OPER	−.002	−.003		
	(.697)	(1.131)		
POP	−.740	−.830	−.750	−.860
	(3.160)	(3.352)	(3.340)	(3.580)
U	−.760	−.603	−.740	−.541
	(3.487)	(2.679)	(3.790)	(2.704)
Y	−10.073	−9.861	−9.955	−9.420
	(3.077)	(2.979)	(3.147)	(2.934)
TIME	.180	.195	.180	.193
	(4.067)	(4.300)	(4.078)	(4.280)
Constant	168.0	183.4	177.4	194.7
	(3.839)	(3.999)	(4.130)	(4.297)
R^2	.31	.30	.29	.28
D.W.	1.80	1.80	1.80	1.81
Number of Observations	140	140	140	140

Notes: (1) *TINT* and *FINT* in natural logarithms.
(2) Independent variables estimated for the quarter in which the hijacking occurred.

Increases in unemployment, which roughly measures a reduction in current legal opportunities, and population, which approximates an increase in potential offenders, reduce the time and flight intervals between successive hijackings. Increases in time (the time trend variable) lengthen the time and flight intervals over time. These results are consistent with the quarterly results on unemployment, population, and time though the coefficients in Table 3 were not significant. Per capita consumption, which has positive effects on the time and flight intervals, is the only variable in Table 4 whose results differ significantly from the predictions of the theoretical analysis.

D. *The Fad Hypothesis*

It is claimed that the pattern of aircraft hijacking in both the United States and abroad can only be understood as a manifestation of a world-wide fad. According to this hypothesis, the concentration of more than 75 per cent of world hijackings since 1961 in the 1968-to-1972 period resulted from a shift in preferences in 1968 in which hijacking became a fashionable form of behavior among a certain class of individuals. Since fads tend to be of short duration as preferences shift, the subsequent decline in hijacking after 1972 is viewed as further evidence to support the fad hypothesis.[26] Implicitly, this approach rejects or greatly discounts the importance of changes in the probability of apprehension and other measures of deterrence to explain the hijacking time series. Thus, the fad hypothesis would interpret the negative association between deterrence variables and hijackings in Tables 3 and 4 as due to a coincidence between changes in deterrence levels and the intensity of the hijacking fad. Although the reliance on fad to interpret hijacking is tautological (that is, when hijacking rises it is fashionable and when it falls it is unfashionable) and a concession that the phenomenon defies rational explanation, it is possible nevertheless to develop an independent estimate of the intensity of this fad. This estimate can then be incorporated into the preceding empirical analysis to differentiate between the deterrence and fad hypotheses.

Suppose the number of hijackings *outside* the United States is included as an independent variable in the U.S. quarterly regressions. On the assumption that hijacking was a world-wide fad, the number of foreign hijackings would approximate variations in the intensity of this fad: that is, when foreign hijackings increased (decreased) the fad was gaining (losing) momentum. Therefore, by holding constant foreign hijackings in the U.S. regressions, one would be able to estimate deterrence effects not confounded by a fad effect. There is, however, an obvious difficulty with this approach. To the extent that U.S. and foreign deterrence levels are positively correlated, variations in foreign hijackings due to changes in deterrence levels in foreign countries would imply similar changes in U.S. deterrence levels. This positive correlation, in turn, would tend to weaken and possibly eliminate the significance of the U.S. deterrence variables.[27]

[26] For an alternative analysis of faddish behavior that assumes unchanging preferences, see George J. Stigler & Gary S. Becker, De Gustibus Non Est Disputandum, 67 Am. Econ. Rev. 76 (1977).

[27] There is evidence of a positive correlation between U.S. and foreign deterrence levels. For example, screening of passengers and searching carryon baggage was instituted in both the United States and some foreign countries in the 1970s, and multi-country treaties were entered into that call for the extradition of hijackers. Further, the correlation between the probability of apprehension in the United States and the rest of the world is about .4 for the quarters between 1961 and 1976.

An alternative test of the fad hypothesis is to substitute foreign for domestic hijackings as the *dependent variable* in the regressions of Table 3. If hijacking is a world-wide fad, and thus the observed negative relationship between deterrence variables and U.S. hijackings is largely coincidental, one should find that the U.S. deterrence variables have about the same impact and degree of significance on the foreign variable as they do on U.S. hijackings. If so, this would suggest that the original deterrence findings in Table 3 are spurious (ignoring the positive correlation between U.S. and foreign deterrence variables). On the other hand, the deterrence hypothesis asserts that the deterrence variables would have their main impact on U.S. hijackings and a substantially weaker impact on foreign hijackings.[28]

Table 5 presents the results of these two tests of the fad hypothesis. The most striking finding of equations (1) and (2), which include foreign hijack-

TABLE 5
QUARTERLY REGRESSIONS WITH FOREIGN HIJACKING (*FHJK*) VARIABLE MODIFIED FIRST DIFFERENCE AND LEVELS
(*t*-values in parentheses)

	U.S. Hijacking (*HJK*)		Foreign Hijacking (*FHJK*)
Independent Variables	CORC ($\hat{\rho}$ = .549) (1)	OLS (2)	OLS (3)
P_a^h	−9.770	−11.140	.684
	(2.904)	(3.309)	(.113)
P_c	−2.654	−5.153	1.546
	(.606)	(1.192)	(.199)
S	−.099	−.081	−.004
	(1.888)	(1.715)	(.047)
P_k	−1.592	−1.909	−1.649
	(1.055)	(1.081)	(.519)
FHJK	.216	.265	
	(3.150)	(3.381)	
R^2		.64	.43
D.W.	1.67	.98	1.74
Number of Observations	59	60	60

Note: All regressions also include as independent variables *OPER*, *POP*, *U*, *Y*, and *TIME*. To simplify the tables, these coefficients are not presented

[28] Two other possibilities must be considered. First one might still find significant effects of U.S. deterrence variables on foreign hijackings if U.S. and foreign deterrence levels are strongly correlated. Second, substitution between U.S. and foreign hijacking may take place. For example, an increase in the level of deterrence in the United States might induce persons to switch to the hijacking of aircraft in foreign countries. Thus, the net effect of U.S. deterrence variables on foreign hijackings depends on the relative strength of two offsetting effects. The fad hypothesis, however, predicts a negative effect, given that one has already observed a negative effect in the U.S. regressions of Table 3.

ings (denoted by *FHJK)* as an independent variable, is that the magnitude and significance of the deterrence variables, with the exception of the conditional probability of incarceration *(P_c),* are comparable to their values when the *FHJK* variable is excluded from the analysis (compare equations (1) and (2) in Table 5 to equations (1) and (2) in Table 3). Although *FHJK* is positive and highly significant in Table 5, its interpretation remains ambiguous.[29] Assuming, however, that the coefficient on *FHJK* reflects the existence of a world-wide fad, one can then compare the relative magnitude of the fad and deterrence effects as follows. The coefficients of the *FHJK* variable indicate, for example, that if the intensity of the fad had been reduced by half during the peak years 1968 to 1972 (that is, if foreign hijackings had been 87 instead of 174), there would have been between 19 and 23 fewer hijackings in the United States or approximately a IS to 19 per cent reduction. In contrast, if the probability of apprehension had been equal to .8 throughout this five-year period instead of its average value of .45, there would have been between 68 and 78 fewer domestic hijackings or a reduction of between 55 and 63 per cent. This comparison suggests that the initial findings on the importance of deterrence in explaining aircraft hijacking is still correct.

Of further interest is regression equation (3) of Table 5 in which *FHJK* is the dependent variable. The fad hypothesis implies that one should find significant negative effects of U.S. deterrence variables on *FHJK* since the relationship between U.S. hijackings and deterrence is alleged to be spurious. This prediction is strongly rejected since two of the four regression coefficients on the deterrence variables are positive and none are statistically significant.[30]

[29] The positive regression coefficient on *FHJK* may reflect a fad or an unmeasured component of deterrence in the United States due to the positive correlation between levels of deterrence in the United States and foreign countries.

[30] I have not experimented with testing the fad hypothesis on the time interval analysis because of the difficulty of defining the relevant foreign hijacking variable. I also performed one additional test on the foreign hijacking variable. Although it is not possible to estimate a complete equation on foreign hijackings—because foreign data on both the deterrence variables (for example, sentence, incarceration, and so forth) and other variables used in the U.S. offense function are not available—one can estimate foreign hijackings as a function of the foreign probability of apprehension and time. The CORC regression estimates for 63 quarters from 1961-1976 are as follows

$$FHJK = \underset{(1.690)}{4.533} - \underset{(1.940)}{5.297}\,FP_a^h + \underset{(1.761)}{.086}\,TIME \qquad D.W. = 2.24 \; n = 62$$

$$FHJK = \underset{(2.072)}{4.966} - \underset{(2.661)}{6.334}\,FP_a^o + \underset{(1.710)}{.082}\,TIME \qquad D.W. = 2.21 \; n = 62$$

where FP_a^h and FP_a^o are respectively the moving averages (prior three quarters) of the probability of apprehension for hijacking and offenders respectively. The above results indicate a significant negative effect of the probability of apprehension on foreign hijackings.

IV. ANTIHIJACKING MEASURES: COSTS AND BENEFITS

The apparent success of public and private policies in drastically reducing the number of hijackings since 1973, the first year of mandatory preboarding searches of all passengers and carryon luggage, raises the questions of how many hijackings were deterred and at what cost?

Before turning to the empirical analysis of these questions, it is useful to consider first the relationship between deterrence and security measures.

A. *Ex Ante and Ex Post Deterrence*

There are two interrelated ways in which security measures deter offenders—for convenience I label them *ex ante* and *ex post* deterrence. Screening passengers at airports for weapons is an example of *ex ante* deterrence. Effective screening means that some potential hijackers are apprehended prior to boarding an aircraft. Therefore, screening lowers the expected returns from hijacking and, other things constant, reduces the number of these offenses.[31] If some offenders are able to avoid detection at the screening stage, however, the subsequent probability of apprehension, which is the probability observed in the hijacking sample, might not be any higher than prior to the imposition of screening. One might observe, for example, a large decline in hijackings (due to mandatory screening) without any increase in the measured probability of apprehension. If this were the case, a finding of no significant effect of the probability of apprehension in the earlier regression analysis need not imply rejection of the deterrence hypothesis. A significant number of prospective offenders might still have been deterred by the unobserved increase in the probability of apprehension at the screening stage.[32]

Ex post deterrence refers to the response of potential offenders to an increase in the probability of apprehension during or after the commission of

[31] Note that the deterrence hypothesis predicts that the total reduction in hijackings due to screening would be a multiple of the number of hijackings aborted at this stage; otherwise, the behavior of potential offenders would be unresponsive to the increase in expected costs from screening. That is, if the total reduction in offenses were identical to the number aborted at the screening stage, then the hypothesis that potential offenders are deterred by higher expected costs would be rejected.

[32] To illustrate, let the number of hijackings be a negative function of the probability of apprehension (P^h) defined as

$$P^h = P_{ms}^h + (1 - P_{ms}^h) P_a^h,$$

where P_{ms}^h is the probability of apprehension at the mandatory screening stage and P_a^h is the probability of apprehension once the hijacking is in progress (usually when the hijacker is aboard the aircraft). Obviously, P^h will rise and hijackings will fall when P_{ms}^h increases while P_a^h remains constant (or even falls slightly). P_{ms}^h, however, is not directly observable. The probability of apprehension utilized in the empirical analysis is P_a^h because an offense is only recorded as a hijacking if the offender avoids detection at the mandatory screening stage.

the hijacking. High *ex post* deterrence is associated, for example, with sky marshals trained to apprehend hijackers once the offense is in progress, or with the treaty between the United States and Cuba in which persons successfully diverting an aircraft to Cuba are now apprehended and returned to the United States. In both instances, the measured probability of apprehension would increase (P_a^h in footnote 32), and the deterrence hypothesis would predict a decline in offenses. Mandatory screening, however, is also likely to affect *ex post* deterrence because the credibility of an offender's threat to harm hostages, and so forth during an attempted hijacking will be weakened by the prospect that he is bluffing and has no effective means to carry out his threat (if he did, how would he have gotten through the screening procedure?).[33]

One can attempt to sort out the *ex post* and *ex ante* deterrent effects by reestimating regressions on a subsample of observations ending in the fourth quarter of 1972. Since this subsample excludes the mandatory screening period, the estimated effects of the deterrent variables are not confounded with the effects of the electronic screening procedure. Put differently, the measured response of potential offenders to a change in the probability of apprehension in the sample period ending in 1972 is net of any increment in *ex ante* deterrence associated with mandatory screening.[34]

Table 6 contains regression equations for the period prior to mandatory screening. Equations (1) and (2) are quarterly time series estimates and should be compared to equation (1) in Tables 3 and 5 that are estimated over the entire sample period ending in 1976. Equations (3) and (4) utilize the time and flight interval variables respectively and should be compared to equations (1) and (3) in Table 4. The relevant comparisons indicate that both the magnitude and statistical significance of the regression coefficients of the various deterrence variables in Table 6 are nearly identical to the estimates

[33] Some casual evidence on this phenomenon can be extracted from the hijacking incidents that took place after the screening procedure went into effect in 1973. In two of the ten recorded hijackings, the offenders were armed but boarded out-of-service aircraft without going through the screening procedure. In another there was a gun battle in the terminal prior to the screening and the offender subsequently boarded the aircraft. Of the remaining seven, all involving persons claiming to be armed, five had no weapons when they were apprehended. This is in sharp contrast to the 27 hijackings in 1972 in which there is no evidence that any of the offenders were not armed. See Federal Aviation Administration–Civil Aviation Security Service, Chronology of Hijackings of U.S. Registered Aircraft and Current Legal Status of Hijackers, as of July 1, 1976 (mimeo). Note that a possible offset to the claim that screening raises the measured probability of apprehension (P_a^h) is that only the more skillful offender is able to avoid being detected at the time of screening. Therefore, one would have a biased sample of offenders after screening was imposed—that is, offenders whose measured probability of apprehension was lower than that of the average offender.

[34] *Ex ante* deterrence was still a factor before the imposition of mandatory screening procedures. For example, passengers meeting a behavioral profile of a hijacker were searched beginning in 1970, and some airlines searched all passengers and carryon luggage.

TABLE 6
QUARTERLY HIJACKINGS (*HJK*), TIME INTERVAL (*TINT*) AND FLIGHT INTERVAL (*FINT*) REGRESSIONS FOURTH QUARTER 1961–FOURTH QUARTER 1972

	HJK		*TINT*	*FINT*
Independent Variables	(1) ($\hat{\rho}$ = .468)	(2) ($\hat{\rho}$ = .464)	(3) OLS	(4) OLS
P_a^A	−12.021	−10.517	3.388	3.422
	(2.896)	(2.616)	(3.766)	(4.042)
P_c	−6.406	−3.054	2.661	2.641
	(1.203)	(.574)	(2.040)	(2.041)
S	−.204	−.155	.041	.042
	(2.381)	(1.823)	(2.020)	(2.122)
FHJK		.198		
		(2.119)		
R^2	—	—	.20	.20
D.W.	1.76	1.61	1.86	1.86
S.E.	2.290	2.184	1.109	1.104
n	44	44	129	129

Note: Equations (1)-(4) also include the following independent variables: *UNEM, Y, POP, OPER* (excluded from equation (4)), and *TIME, TINT,* and *FINT* variables are in natural logarithms.

based on the full sample.[35] This shows (somewhat surprisingly) that the earlier findings on the significance of deterrence variables are not sensitive to the exclusion of the 1973-to-1976 period.[36]

One can use the regression coefficients of Table 6 to forecast the number of additional hijackings that would have taken place between 1973 and 1976 if (a) mandatory screening of passengers and carryon baggage had not been in force, and (b) the probability of apprehension had not increased after 1972 but instead had remained equal to its 1972 level of .81 (in part, due to the assumed absence of screening). Estimates of the number of additional hijackings, presented in column (1) of Table 7, range from 41 to 60 or an average of 2.7 to 4.0 more offenses per quarter during the 1973-to-1976 period.[37] That is, absent mandatory screening and assuming that the proba-

[35] I have also reestimated equations for the 1961-1972 period using alternative measures of the probability of apprehension, sentence, and so forth that were presented in earlier tables. These measures are not presented here because the regression coefficients and *t*-values were nearly identical to the estimates based on the full sample period. Note that the conditional probability of being killed (the P_k variable) is not included in the 1961-1972 equations because no one was killed until the third quarter of 1971.

[36] One might have expected the deletion of the 1973-1976 period to weaken greatly the effect of the deterrence variables because this period was one of few hijackings and relatively high values of the probability of apprehension.

[37] To compute the predicted values I used the 1961-1972 regression coefficients and the actual 1973-to-1976 quarterly values of all variables except the probability of apprehension. The latter is set equal to its 1972 value of .81. The actual number of hijackings that occurred in each

TABLE 7
PREDICTED NUMBER OF ADDITIONAL HIJACKINGS
FIRST QUARTER 1973–THIRD QUARTER 1976

Regression	Additional Hijackings, Probability of Apprehension 1972 Level (1)	Probability of Apprehension = Estimated Values '73-'76		Probability of Apprehension = .98 in '73-'76	
		Ex Ante Deterrence (2)	*Ex Post* Deterrence (3)	*Ex Ante* Deterrence (4)	*Ex Post* Deterrence (5)
OLS	60	41	19	33	27
CORC	67	46	21	37	30
OLS (foreign hijackings included)	41	21	20	12	29
CORC (foreign hijackings included)	50	32	18	24	26

Notes: 1. Estimates based on quarterly hijacking regressions from fourth quarter 1961–fourth quarter 1972. Note that the OLS coefficients on the deterrence variables were nearly identical to the CORC coefficients in Table 6 though the significant levels of the former were slightly lower.
2. The 1972 value of the probability of apprehension (P_a^{72}) equals .81.

bility of apprehension remained at its 1972 level, total hijackings in the United States would have been between 52 and 71 compared to the 11 hijackings that actually occurred between 1973 and the third quarter of 1976. As expected, the lower range of estimates (41 and SO) in column (1) of Table 7 occur when foreign hijackings is included as an independent variable in the regression equation. Since the regression coefficient of the foreign hijacking variable is positive (Table 6) and the hijacking fad, measured by foreign hijackings, diminished after 1973 compared to the 1968-to-1972 period, the predicted number of hijackings after 1973 tends to fall when foreign hijackings is included in the U.S. hijacking regressions.[38]

Previously, I discussed the distinction between *ex ante* and *ex post* deterrence. *Ex ante* is primarily associated with screening procedures and *ex post* with measures that increase the likelihood of apprehension once the hijacking is in progress. One can partition the estimated reduction in hijackings

quarter from 1973 to 1976 is then subtracted from the predicted number to estimate the number of additional hijackings that would have taken place absent screening and assuming a probability of apprehension of .81.

[38] By including foreign hijacking in the regression equation, however, one probably understates the number of additional U.S. hijackings that would have taken place after 1972. Foreign hijackings declined, in part, between 1973 and 1976 because of an increase in the probability of apprehension abroad. But this increase is positively correlated with an increase in the probability of apprehension in the United States. Thus, foreign hijacking picks up the effect of an increased probability of apprehension in the United States, violating the assumption of a constant probability of apprehension between 1973 and 1976 equal to its 1972 value.

(column (1) of Table 7) into its *ex ante* and *ex post* components by predicting, as before, the number of offenses per quarter beginning in 1973 but letting the probability of apprehension take its actual value in each quarter, not its 1972 value. The differences between the predicted and actual hijackings now measures the reduction *not* explained by the subsequent increase in the probability of apprehension between 1972 and 1973-1976. Column (2) of Table 7 contains these estimates of *ex ante* deterrence. *Ex post* deterrence (column (3)) is simply the difference between the estimates in columns (1) and (2).[39] For purposes of comparison I also computed an upper limit of the importance of *ex post* deterrence by assuming that the offender's estimate of the probability of apprehension equaled .98 in all quarters beginning in 1973.[40] This modification produces an increase in *ex post* deterrence of about nine hijackings (compare columns (3) and (5) of Table 7).

Overall, the impact of *ex ante* deterrence on reducing the number of hijackings since 1973 appears to be greater than that *of ex post* deterrence; the former accounting for about 55 per cent of the number of hijackings deterred in the 1973 to 1976 period. (The one exception is the estimate in row 3 of columns (4) and (5) of Table 7.) This result is not surprising because of the already high (.81) probability of apprehension in 1972. Thus increases in the probability, even with a relatively large response by potential offenders, would at most reduce the number of offenses by three per quarter. Of further interest is the relative importance of the treaty with Cuba. If the treaty were the sole cause of the increased probability of apprehension between 1973 and 1976, then columns (3) and (5) would measure the treaty's impact. Surely, this would overstate the impact since the increased probability in 1973 to 1976 was in part due to the greater likelihood that offenders were unarmed (that is, the screening effect). There is another reason, however, for believing the *ex post* estimates in columns (3) and (5) exceed the effect of the treaty: the number of offenders attempting to reach Cuba had sharply fallen between 1969 and 1972 (from more than 95 per cent to 25 per cent). Assuming that the latter proportion would have persisted through 1976, then about 75 per cent of *ex post* deterrence would be unrelated to the treaty.[41]

[39] Alternatively, the estimates in column (3) can be derived by summing $\beta_1 (P_a^h \text{ (actual)} - P_a^h \text{ (1972)})$ for the 1973-1976 quarters where β_1 is the regression coefficient on the probability of apprehension, "actual" denotes the values of P_a^h in 1973-1976, and "1972" denotes the 1972 value.

[40] Note that .98 represents only a small increase over the moving average estimates between 1973 and 1976 (which is the basis of column (3)). The latter estimates contain probabilities of less than .98 because quarters prior to 1973 are averaged in the 1973 estimates and some missing quarters (that is, no hijackings) were assigned probability estimates less than .98.

[41] A final issue concerns the interpretation of *ex ante* deterrence. There is no way to be sure that the numbers in this category in Table 7 represent deterrence in the sense of potential offenders substituting away from an activity in response to a reduction in the probability of

B. *The Costs and Benefits of Mandatory Screening*

Data on the costs of operating the mandatory screening program are available only for 1974. In 1974, U.S. air carriers and airports spent approximately $71.56 million to screen passengers enplaned in the United States.[42] Assuming identical real expenditures in 1973, 197S, and 1976 and adding $1.97 million of federal government expenditures on magnetic equipment to screen passengers, total expenditures (in 1974 dollars) from 1973 through the third quarter of 1976 on mandatory screening would equal $270.32 million.[43] This figure, however, probably overstates the net increase in direct security costs from 1973 to 1976 compared to the years prior to mandatory screening because no allowance is made for a reduction in other security

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success. It is conceivable that all of the 12-to-46 reduction in hijacking in the *ex ante* category represents persons apprehended at the screening stage who are not deterred in the above sense. The Federal Aviation Administration's Semi-Annual Report to Congress on the Effectiveness of the Civil Aviation Security Program contains data on the number of persons screened and weapons (by type) detected. To illustrate, in 1975 more than 200 million persons were screened at airports, 4,783 firearms and 46,318 knives were detected, and 2,464 persons were arrested for various offenses such as weapons violations, giving false information, narcotics, and immigration violations. The number of firearms detected, persons arrested, and so forth at the preboarding stage greatly exceeds the number of hijackings that took place in the years before 1973. Thus, one could not utilize such information on firearms to estimate directly the number of would-be hijackers apprehended at the screening stage. The FAA, however, also reports on various incidents at airports that might have involved potential hijackers. In 1975 the FAA estimates that there were 35 such incidents. This number, however, is greater than my estimate for 1975 of *ex ante* and *ex post* deterrence combined. Therefore, it does not appear feasible to use the FAA data to estimate the number of hijackings prevented at the preboarding stage, which would then be subtracted from my estimates of *ex ante* deterrence to compute a corrected *ex ante* deterrence measure.

[42] Expenditures on the screening program for 1974 are contained in the Dep't of Transportation and Related Agencies Appropriations for 1976, Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives, 94th Congress, 1st Session, pt. 5, 955-59 [hereinafter cited as Hearings]. These expenditures include both the costs of labor services (for example, screening personnel, armed guards) and some capital services (for example, depreciation of X-ray equipment used for baggage inspection). Note that these expenditures are defined as the "incremental" security costs of the mandatory screening program and thus represent the amount the airlines are entitled to recover via a fare increase. (See C.A.B., Docket 25315, Airport Security Charges Proposed by Various Scheduled Air Carriers, June 4, 1974 and Sept. 23, 1974.) Finally note that total screening expenditures in 1974 were actually $75.45 million not $71.56 million as given in the text. The former figure includes expenditures by U.S. air carriers on passengers enplaned outside the United States (about 5% of passengers carried by U.S. carriers). These expenditures are excluded from my estimate of screening costs by assuming that the ratio of screening expenditures of U.S. enplaned to total enplaned passengers on U.S. carriers is proportional to the ratio of passengers enplaned in the United States (including Puerto Rico, the Virgin Islands, Guam, and American Samoa) to the total number of enplaned passengers on U.S. carriers.

[43] In December 1972, $2.5 million was appropriated by the federal government to purchase metal detection devices (see Hearings, *supra* note 42, at 952). Assuming a five-year useful life (which is the life allowed for X-ray equipment) and adjusting for inflation in 1973, this amounts to $2.63 million in 1974 dollars of which $1.97 million is the share for the 15 quarters between 1972 and 1976.

costs. In particular, federal government expenditures (in current dollars) on civilian aviation security positions (for example, air marshals and other security personnel) declined from an average of $28.45 million per year in the two years prior to mandatory screening to an average of $12.58 million per year in the 1973-1976 period. Adjusting for this factor yields an estimate of the net increase in costs of the mandatory screening program of $194.24 million (in 1974 dollars).[44] Note that this estimate ignores an important element of security costs, the additional time and inconvenience to passengers resulting from screening. Unfortunately, I have no information on these indirect costs and thus the analysis that follows only considers the net increase in monetary costs of the screening program.[45]

Data on the increase in security costs due to mandatory screening can now be combined with the hijacking projections of Table 7 to obtain several estimates of the average costs of deterring a single hijacking between 1973 and 1976.[46] If one assumes initially that mandatory screening is responsible for deterring all the additional hijackings that would have occurred between 1973 and 1976 in the absence of both screening and an increase in the probability of apprehension (that is, the estimates in column (1) of Table 7), the average costs of preventing *a.single* hijacking range from $3.24 to $4.74 million depending on whether foreign hijacking is included as an independent variable in the U.S. regressions.[47] This range of estimates is likely to understate the true costs because it assumes no deterrent effect of the treaty

[44] Federal expenditures on civilian aircraft security positions and the amounts deducted from the costs of the screening program are contained in the table below.

	Millions of Dollars[1]						
	1971	1972	1973	1974	1975	1976	Total
Current dollars	28.0	28.9	27.4	12.3	4.9	5.7	
1974 dollars	33.95	33.64	30.15	12.3	4.48	4.96	
Amount[2] deducted			3.65	21.5	29.32	28.84[3]	76.08

[1] Data obtained from Mr Henry D. Williams of the FAA. The figures refer to funding for civil aviation security positions that include deputy U.S. marshals, customs security officers, personnel from the office of the secretary of transportation and the FAA, and in 1971 some military personnel.

[2] Amounts deducted based on the difference between average expenditures 1971-72 and actual expenditures 1973-76 (all in 1974 dollars).

[3] In 1976 I deducted .75 of $28.84 million to correspond with the projections that end with the third quarter of 1976.

[45] These indirect costs may exceed the direct monetary cost of the screening program since the latter is less than 50 cents per enplaned passenger.

[46] The average cost of deterring a single hijacking equals the net increase in security costs between 1973 and 1976 (=$194.25 million) divided by the number of hijackings prevented (see Table 7).

[47] Only the OLS estimates of Table 7 are used in these calculations.

with Cuba. Alternatively, if one assumes that all *ex post* deterrence in Table 7 is due to the treaty (which overstates the treaty's impact because it ignores the screening effect on *ex post* deterrence), the average costs of deterring a *single* hijacking rise to between $4.74 and $9.25 million.

What the above estimates make clear are the substantial costs allocated to deterring a single hijacking. I have not attempted to weigh these costs against the dollar value of the benefits because that would require estimates of the monetary equivalent of the added time and inconvenience costs to hijacked passengers, the dollar value of any additional risk of death and injury, fuel costs, the user cost of the airplane, labor costs, and so forth.[48] Nevertheless, some insight can be gained into the magnitude of the benefit that would be required to justify the relatively large security expenditure by posing the following hypothetical question. What would the dollar costs to a hijacked passenger have to equal to make the reduction in expected costs from being hijacked equal to the increase in security costs associated with the mandatory screening program? Mandatory screening has led to a .000003449 to .000001207 estimated reduction in the probability of a flight being hijacked at a net increase in security costs to an enplaned passenger in the United States of approximately 26.46 cents.[49] This change in probability, in turn, would justify an expenditure of 26.46 cents if the monetary equivalent of the costs of being hijacked to the average passenger were in the range of $76,718 to $219,221 (see Table 8). Put differently, if one were risk neutral, he would he willing to spend 26.46 cents on security providing the dollar equivalent of the hijacking loss was in the range of $76,718 to $219,221.[50]

V. CONCLUDING REMARKS

The present study of U.S. aircraft hijacking can be viewed as a contribution to the rapidly growing literature on the economics of deterrence.[51]

[48] A further benefit from mandatory screening, which should be included in any cost-benefit calculation, is the reduction in *other* crimes resulting from screening (for example, the detection of narcotics).

[49] In 1974 the number of enplaned passengers in the United States was 195,756,000 (see Hearings, *supra* note 42, at 944-59) and the net increase in costs of the screening program for a single year equals $51.8 million ($194.25 million times 4/15). The average cost per enplaned passenger during the entire 1973-1976 period is then estimated to equal $.2646 (=$51.8/195.756). Note that I am ignoring the distributive consequences of the screening program (financed by passengers, air carriers, and airports) compared to prescreening security program (financed by tax revenues).

[50] If the indirect costs of the mandatory screening program (that is, time costs of screened passengers) were included, the estimate of the dollar equivalent of the hijacking loss would of course rise.

[51] A useful though somewhat outdated summary of the economic literature is contained in Gordon Tullock, Does Punishment Deter Crime?, Public Interest, Summer 1974, at 103. The most

TABLE 8
PROJECTED HIJACKING LOSSES OF A SINGLE PASSENGER, 1973-1976

Quarterly Regression (see Table 7)	Change in Probability of Flight Being Hijacked: Mandatory Screening Deters all Projected Hijackings (1)	Change in Probability of Flight Being Hijacked: Hijacking Deterred by Mandatory Screening = *Ex Ante* Deterrence (2)	Dollar Losses Assuming Risk Neutrality: (3) = .2646/(1)	Dollar Losses Assuming Risk Neutrality: (4) = .2646/(2)
OLS	.000003449	.000002357	$76,718	$112,261
OLS (foreign hijackings included)	.000002357	.000001207	112,261	219,221

Note: The following example illustrates the method of calculating the change in probability of being hijacked. Between 1973 and the third quarter of 1976 there were approximately 17,397,838 U.S. air carrier flights (= air carrier operations ÷ 2). If 60 hijackings were deterred by mandatory screening (column (1) of Table 7), the reduction in the probability of a flight being hijacked equals 60/17,397,838 (= .00000349).

Although the basic approach and empirical findings of this study are similar to the many other economic studies of deterrence, which typically find significant deterrent effects of conviction rates and sanctions on the amount of crime, it differs from these studies in several respects. I have focused on a narrowly defined type of offense that experienced an unprecedented increase in the 1968-to-1972 period followed by a dramatic decline thereafter. In contrast, other studies usually analyze broadly defined crimes that have increased throughout the 1960s and 1970s. I have utilized data on individual offenses, measured by time and flight intervals between successive hijackings, in addition to quarterly data to estimate offense functions. Other studies employ either aggregate cross-sectional or time series observations to estimate deterrence effects. Finally, I have attempted to measure the benefits attributable to the rapid introduction in 1973 of a new and important security procedure, the mandatory screening of passengers and carryon luggage. No comparable innovation in security has been introduced to deter other types of crime.

The main findings of this paper can be summarized as follows.

1. Increases in the probability of apprehension, the conditional probability of incarceration, and the sentence are associated with significant reductions in aircraft hijackings in the 196l-to-1976 time period. These findings are based on two methods of estimating the rate of hijackings, a quarterly time series and the time or flight intervals between successive hijackings, and alternative estimates of the deterrence variables.

2. To test an alternative explanation of hijackings, which I term the "fad" hypothesis, I included foreign hijackings as an independent variable in regressions on U.S. hijackings. Since the number of foreign hijackings coincide with variations in the intensity of the worldwide hijacking fad, the inclusion of this variable allows one to differentiate between deterrence and fad effects. Although foreign and U.S. hijackings are positively correlated, the deterrence variables remain highly significant and appear to be the relatively more important determinants of U.S. hijackings.

3. Regression estimates from the sample period ending in 1972 were used to forecast the number of additional hijackings that would have taken place between 1973 and 1976 if (a) mandatory screening had not been instituted and (b) the probability of apprehension (once the hijacking is attempted) had remained constant and equal to its 1972 value. Under these assumptions,

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significant recent contributions are two papers by Isaac Ehrlich on capital punishment (see The Deterrent Effect of Capital Punishment: A Question of Life and Death, 65 Am. Econ. Rev. 397 (1975); and Capital Punishment and Deterrence: Some Further Thoughts and Additional Evidence, 85 J. Pol. Econ. 741 (1977)). For a critical review of the economic literature see Daniel Nagin, General Deterrence: A Review of the Empirical Evidence, in Deterrence and Incapacitation: Estimating the Effects of Criminal Sanctions on Crime Rates 95 (Alfred Blumstein, Jacqueline Cohen, & Daniel Nagin eds. 1978) (Nat'l Acad. Sci.).

there would have been between 41 and 67 additional hijackings compared to the 11 that actually occurred in the 1973 to 1976 period.

4. Although the mandatory screening program is highly effective in terms of the number of hijackings prevented, its costs appear enormous. The estimated net increase in security costs due to the screening program (which does not include the time and inconvenience costs to persons searched) is $194.24 million over the 1973-to-1976 period. This, in turn, translates into a $3.24-to-$9.25 million expenditure to deter a single hijacking. Put differently, if the dollar equivalent of the loss to an individual hijacked passenger were in the range of $76,718 to $219,221, then the costs of screening would just offset the expected hijacking losses.

APPENDIX

PROBABILITY OF APPREHENSION

Table Al presents a least squares estimate of the probability of apprehension *(P_n)* for 154 hijackings.[52] The dependent variable, P_a, is a dummy variable that equals 1 if the offender is apprehended (within 12 months of the hijacking) and 0 otherwise.[53] The independent variables included in the linear probability function and their predicted effects are as follows:

1. *Flight Crew Members (FLCR).* An increase in the number of flight crew members on the hijacked aircraft is equivalent to an increase in the quantity of resources available to protect the aircraft. Thus, an increase in *FLCR* should increase the difficulty of a successful hijacking and raise the probability of apprehension.[54]

2. *Offenders per Hijacking (OFD).* Suppose planning and coordination costs increase with the number of offenders involved in a hijacking. Since a higher expected return would be required to offset these added costs, one expects a negative effect of *OFD* on the probability of apprehension.

3. *Age of Offenders (AGE).* In the human capital literature, there are offsetting effects of age on earnings, which are estimated by including age and age-squared variables in an earnings function. Age is initially associated with higher earnings as

[52] The number of observations here differs from the number (143) in the text because the probability estimates were computed prior to adjusting the domestic hijacking data for hijackings of U.S. registered aircraft in foreign countries (see note 1 of Table 1, *supra*).

[53] In multiple-offender hijackings, all offenders were either apprehended or not. Hence P_a is either 0 or 1 in multiple-offender hijackings. Logit or probit techniques are more appropriate than ordinary least squares when dealing with a dichotomous dependent variable. I fitted some probability functions using logit analysis and the resulting estimates were similar to ordinary least squares. Only the latter results are presented in the Appendix.

[54] There is a possible selection bias, however, in that the size of the flight crew is a variable of choice in the offender's hijacking decision. He can, for example, reduce the flight crew by selecting a smaller aircraft. This implies that there may be other advantages to the offender of a larger aircraft (for example, greater range) which affect the probability, so that on balance the probability does not rise with an increase in the flight crew.

the positive effect of experience dominates, and subsequently with a decline in earnings as depreciation of skills offsets the effects of greater experience. One might expect similar effects on the probability of apprehension for hijackings (or crime in general)—a negative sign on age and a positive sign on age-squared.

4. *Aircraft Security Measures (SKY, SEARCH).* I use two dummy variables to denote periods in which security was intensified. *SKY* takes the value of 1 (and 0 otherwise) for hijackings that occurred between 1970 (fourth quarter) and 1972 (fourth quarter), the period where sky marshals were flying on selected flights and informal screening was used by several airlines. Since this denotes a greater allocation of resources to deterrence, one predicts a positive impact of *SKY* on the probability of apprehension. *SEARCH* equals 1 (and 0 otherwise) for hijackings that occurred after mandatory screening was introduced in 1973. Given the added deterrence of screening, one expects a positive coefficient on this variable.

5. *Flight Operations (OPER).* One would predict that the greater the number of flight operations during the quarter in which a hijacking took place, the smaller the amount of airport and aircraft security per flight, and hence the lower the probability of apprehension.

TABLE A1
PROBABILITY OF APPREHENSION, 154 HIJACKINGS

	Regression Coefficients (and *t*-statistics)								
CONSTANT	*FLCR*	*OFD*	*AGE*	$(AGE)^2$	*SKY*	*SEARCH*	*OPER*	R^2	*D.W.*
2.197	−.174	−.162	−.021	.00028	.201	.490	−.001	.26	1.90
(3.93)	(1.74)	(3.84)	(1.31)	(1.27)	(2.50)	(3.32)	(1.44)		

All variables in Table A1, except for *FLCR,* are in the predicted direction and are either significant or marginally significant. *OFD, AGE,* and *OPER* reduce the probability of apprehension, whereas $(AGE)^2$, *SKY,* and *SEARCH* raise this probability. The coefficients of *AGE* and $(AGE)^2$ indicate, for example, that the probability of apprehension is lowest for an offender who is 37.5 years of age.[55] Of further interest is that the mandatory search variable has a significantly greater impact on the probability of apprehension than the sky marshal variable.[56] As indicated in the text, this increase in deterrence is produced only by a substantial increase in expenditures on deterrence. The negative sign of *FLCR* may be due to the positive correlation between the size of the aircraft and the number of flight crew members. Since a larger aircraft has a greater range, this reduces the number of refueling points (possibly to zero), which in turn may reduce the likelihood that the hijacker is overpowered prior to reaching his destination.

[55] The joint effect of *AGE* and $(AGE)^2$ is not statistically significant.

[56] The results of the *SKY* and *SEARCH* variables are sensitive to the inclusion of a time trend variable. When time is entered, these coefficients become insignificant, whereas time is positive and marginally significant. The explanation for this result is that the two dummy security variables are highly correlated with time.

As noted in the text, quarterly estimates of the probability of apprehension were utilized to fill in missing quarter values of the probability of apprehension (see note IS *supra).* The average quarterly values of the variables included in Table Al plus a time trend variable were used in the quarterly probability estimate. The results are quite similar to the regression on the individual observations.

Sentence

The results of the sentence regression is presented in Table A2. The variables included in this regression, in addition to *OFD* and *AGE,* are a set of variables measuring a variety of factors that are likely to bear on the defendant's sentence. These include a foreign variable *(FOR)* that equals 1 if the offender is sentenced in a foreign country; a race variable *(WHITE)* that equals 1 if the offender is white (and 0 if he is black or Spanish); an extortion variable *(EXT)* that equals 1 if the offender attempted to extort money from the airline; a time variable *(DTS)* that equals the quarter in which the defendant is sentenced; and two dummy variables *(INC* and *SUC)* that denote the point during the hijacking in which the offender is apprehended. Specifically, in an incomplete *(INC)* hijacking the offender gains control of the aircraft but does not reach his destination. In a successful *(SUC)* hijacking the offender reaches his destination but is subsequently apprehended and sentenced. The omitted variable is an unsuccessful hijacking in which the offender is apprehended prior to gaining control of the aircraft (for example, he is apprehended on the ground prior to takeoff). If marginal deterrence is operating, the coefficients on both *INC* and *SUC* should be positive, and the coefficient on *SUC* should be greater than on *INC.*

TABLE A2
SENTENCE (IN YEARS) OF 56 OFFENDERS

	Regression Coefficients (and *t*-statistics)								
CONSTANT	*FOR*	*EXT*	*WHITE*	*AGE*	*OFD*	*INC*	*SUC*	*DTS*	R^2
22.42	−24.34	23.23	−6.41	.139	−3.04	6.10	13.63	−.225	.58
(2.34)	(4.78)	(6.12)	(1.62)	(.844)	(1.39)	(1.28)	(2.80)	(1.62)	

Although there is little theory to support the specification of the sentence function, the results are nevertheless interesting. Apprehension and sentencing in a foreign country lead to a significantly lower sentence while extortion leads to a significantly higher sentence. Marginal deterrence is observed since the sentence increases as one moves from unsuccessful to incomplete (though the coefficient on *INC* is only marginally significant) to successful hijacking. Of the remaining variables, one observes negative effects of the race and offender variables and no significant effects of the age and time of sentence variables.